CCN SPECTRAL MEASUREMENTS

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DRI Cloud condensation nuclei (CCN) spectrometers.

Produce a field of supersaturations (S) by thermal diffusion of temperature and water vapor between two parallel plates, where cloud droplets grow on hygroscopic sample particles.
More hygroscopic (e.g., larger) particles produce larger cloud droplets.
Continuous flow through the cloud chamber (~30s) then into an optical particle counter (OPC). CCN spectrum is deduced from the OPC droplet spectrum. A calibration curve relates OPC droplet size to particle hygroscopicity (critical supersaturation—S_c).

Calibration is done with nuclei of known composition (e.g., NaCl) and size (differential mobility analyzer—DMA—electrostatic classifier--EC).

Assumes that all CCN with the same S_c regardless of composition (or size) produce the same droplet sizes. Calibration holds only if all chamber parameters (i.e., flows and temperatures) remain constant.

S_c inversely proportional to number of soluble ions. Traditionally CCN plots are cumulative because clouds act cumulatively on the aerosol— all nuclei with $S_c <$ cloud S produce “activated” cloud droplets.

Also previous CCN instruments had too few data points to produce a differential spectrum.
DRI CCN spectrometers have enough data points to produce differential spectra.

Spectrometry is foiled by instrumental broadening and coincidence.

Broadening is more of a problem for steep spectra.

Coincidence is more of a problem for higher concentrations.

S range 1-0.02% (i.e., 101-100.02% RH) cloud S range.
Higher S_c for smaller (less hygroscopic) particles.

1% S_c –   25 nm NaCl

0.1% S_c –110 nm NaCl

0.02% S_c –310 nm NaCl

other compositions must have larger sizes for the same S_c

Two DRI CCN spectrometers

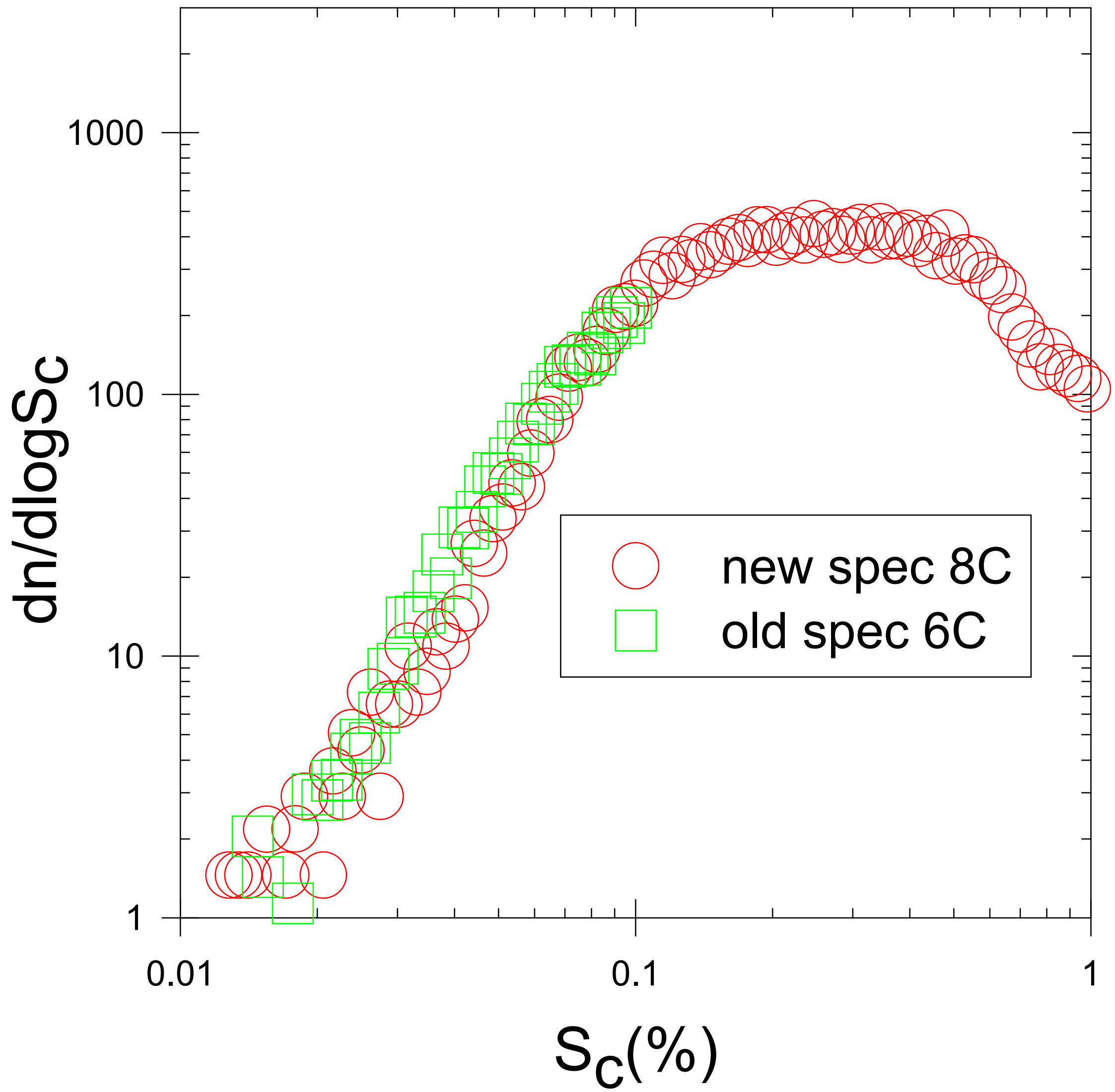
1. redundancy
2. different S ranges of better validity; check in overlapping range.
3. Calibrations
4. Volatility
5. Size versus S_c
6. One on ground, one in air?

Comparisons of two CCN spectrometers operating at different supersaturation (S) ranges suggest validity over the full extended S range.

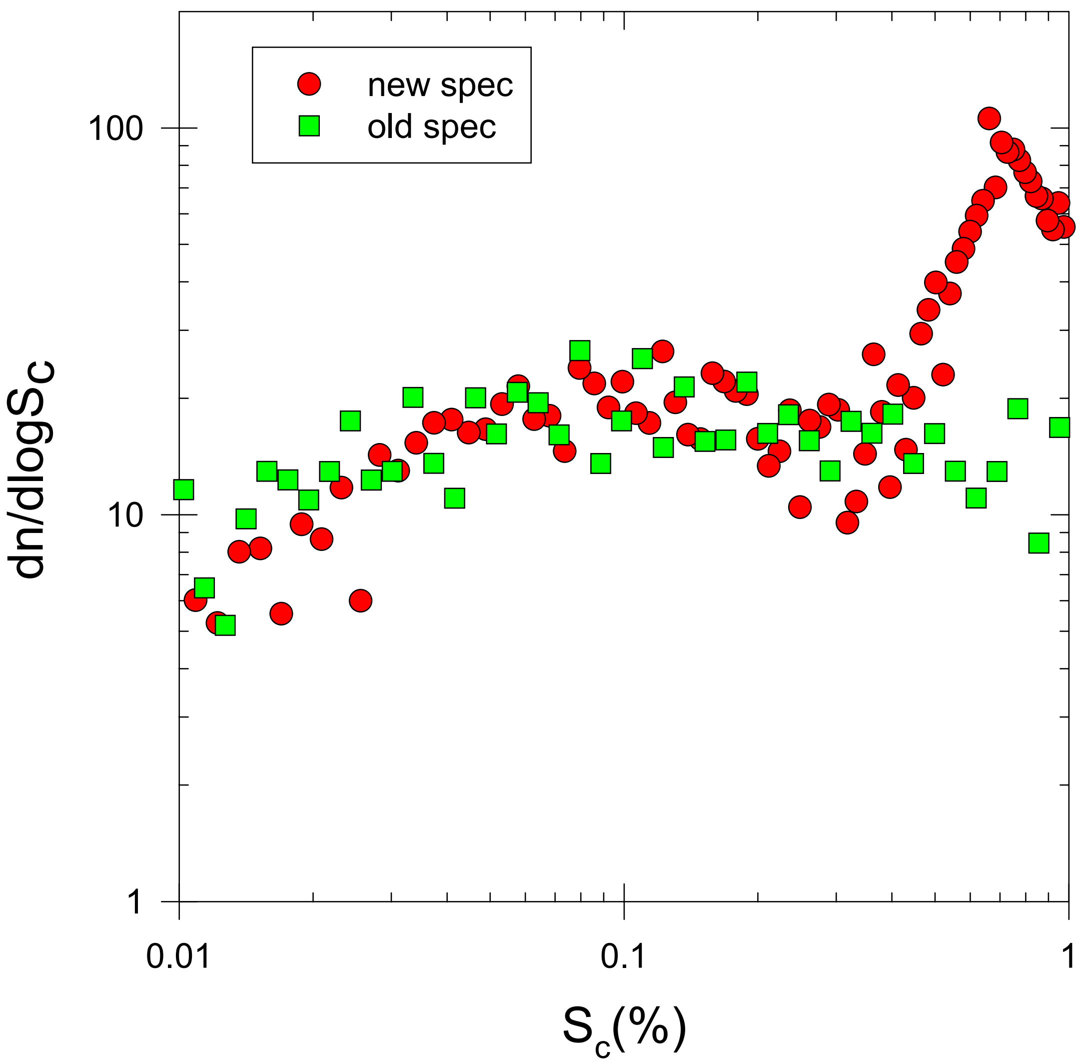
Extension the traditional CCN (Aitken) range below 0.1% to Large Nuclei, is necessary because a large proportion of CCN have $S < 0.1\%$. This is needed because:

- Many clouds have $S < 0.1\%$
- Static closure—aerosol and CCN
- Dynamic closure—CCN and cloud droplets.
- Large nuclei are embryos for precipitation.
- Droplet spectral width.
- Interface with giant nuclei.
- CCN sizes.

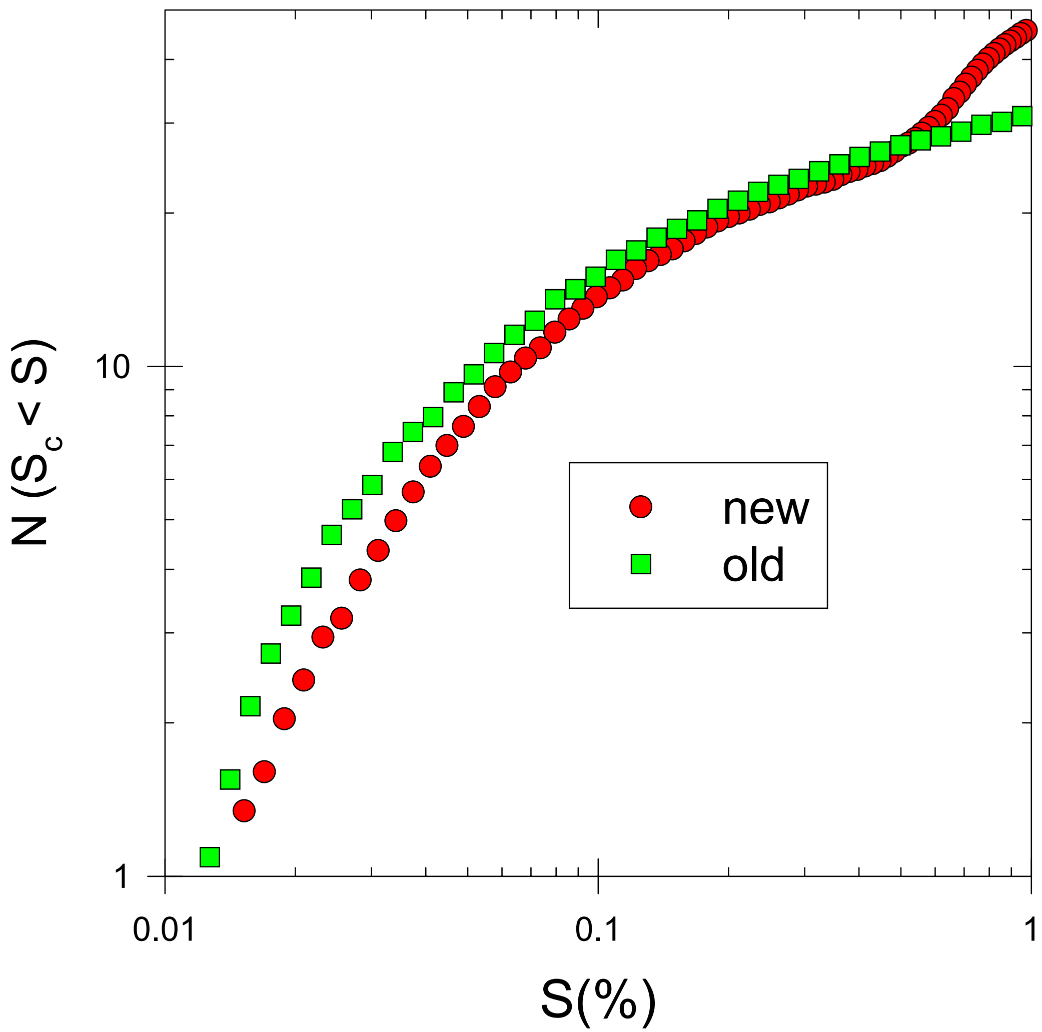
Sep 28, 2004; 1954-2000 at Reno, NV
new spec. delta Tmax = 8 C
old spec. delta T max = 6 C
outside air CN = 17416 cm^{-3}
CCN @ 1%S 855 cm^{-3}



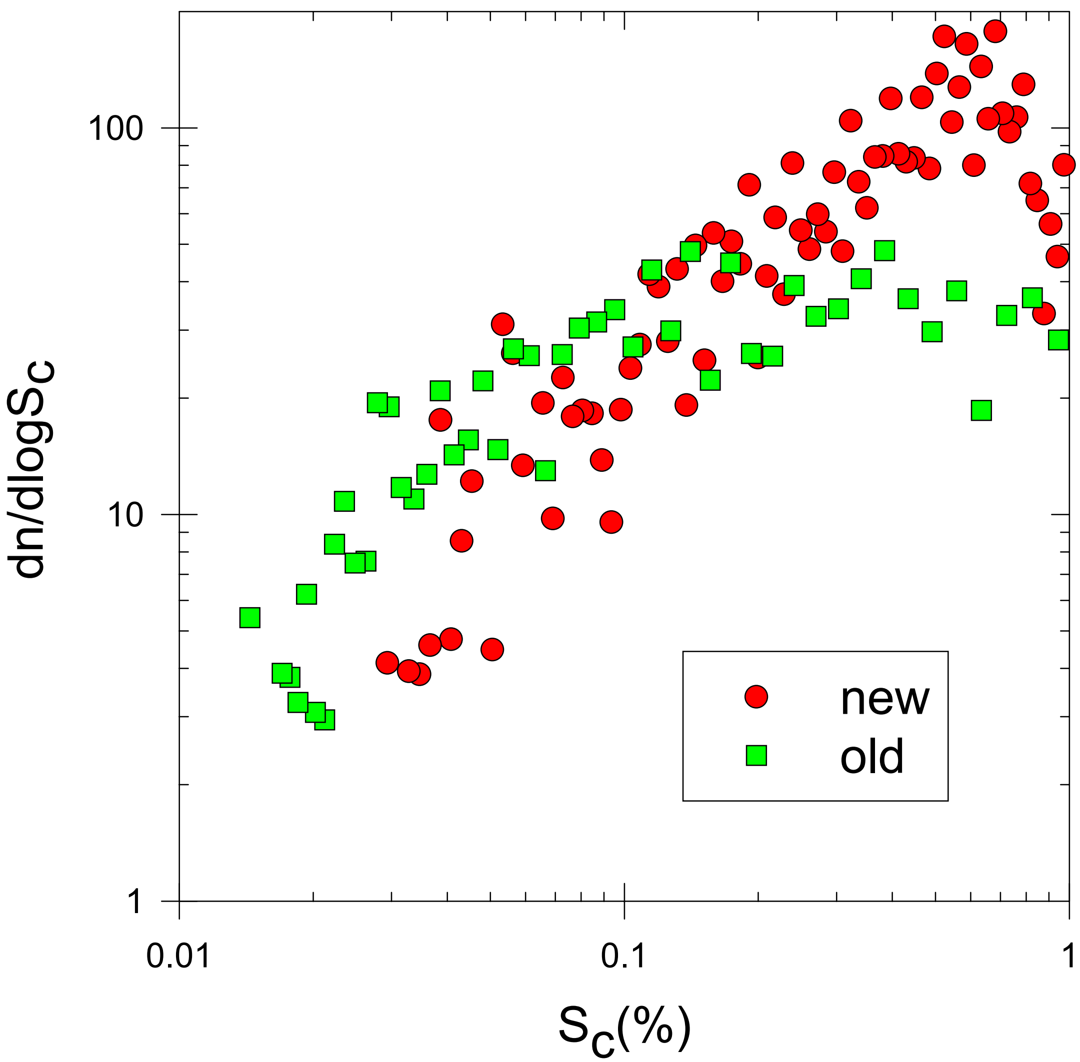
Dec 10, 2004 1226:00-1228:00 AST (1626:00-1628:00)
C-130 RICO, Antigua 946 mb
CN 194 cm^{-3} CCN @ 1% 47 cm^{-3}



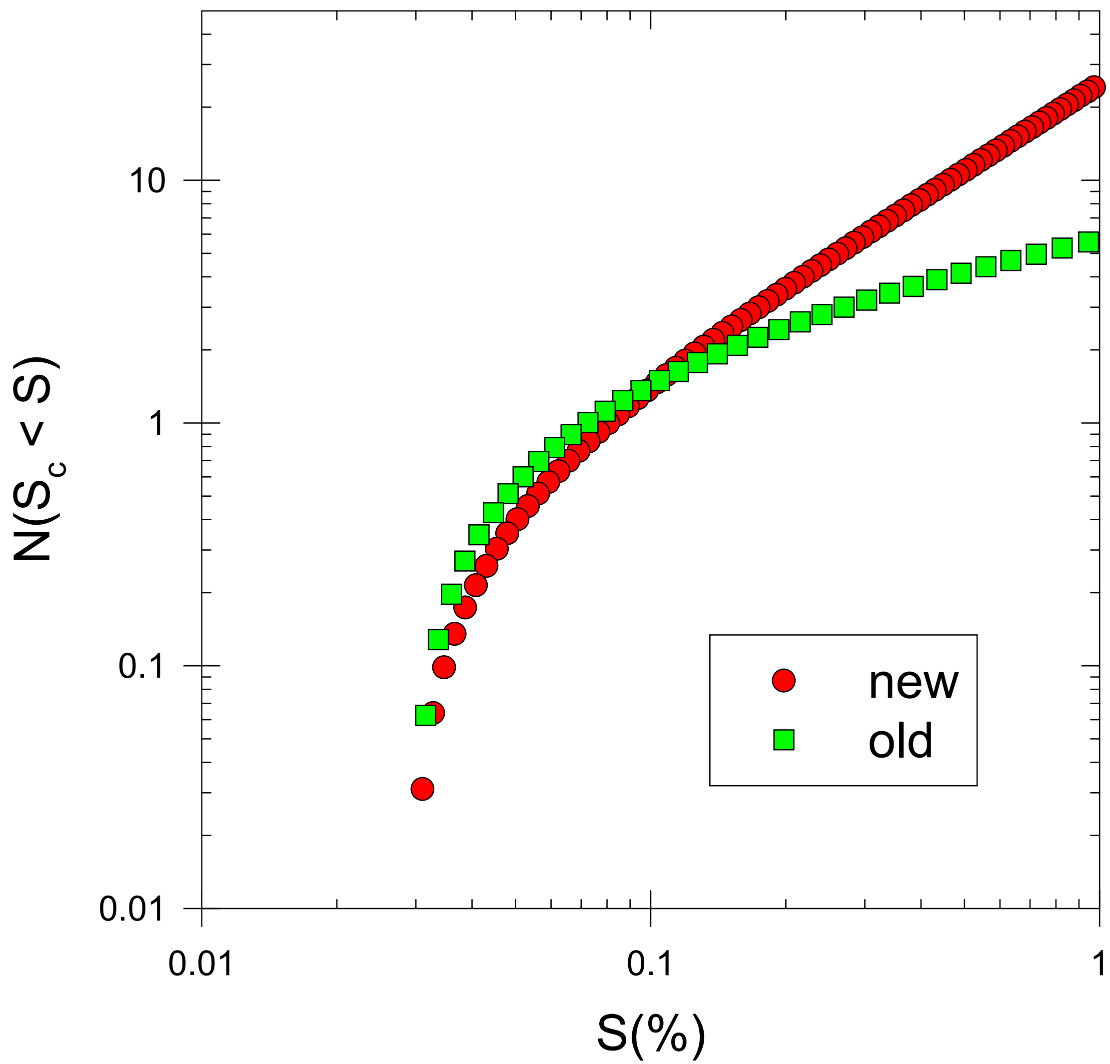
Dec 10, 2004 1226:00-1228:00 AST (1626:00-1628:00)
C-130 RICO, Antigua 946 mb
CN 194 cm^{-3} CCN @ 1% 47 cm^{-3}
cumulative distributions

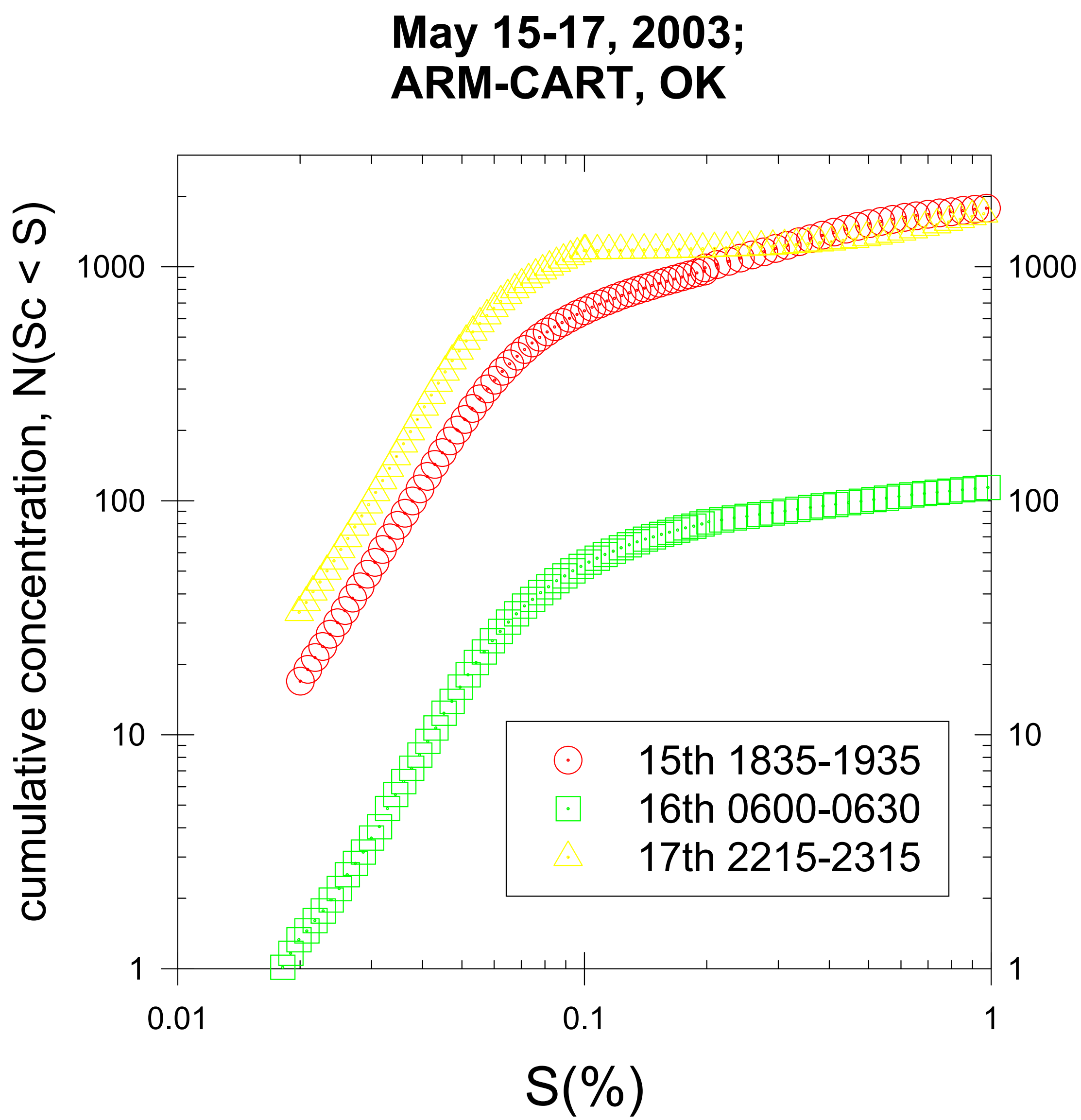


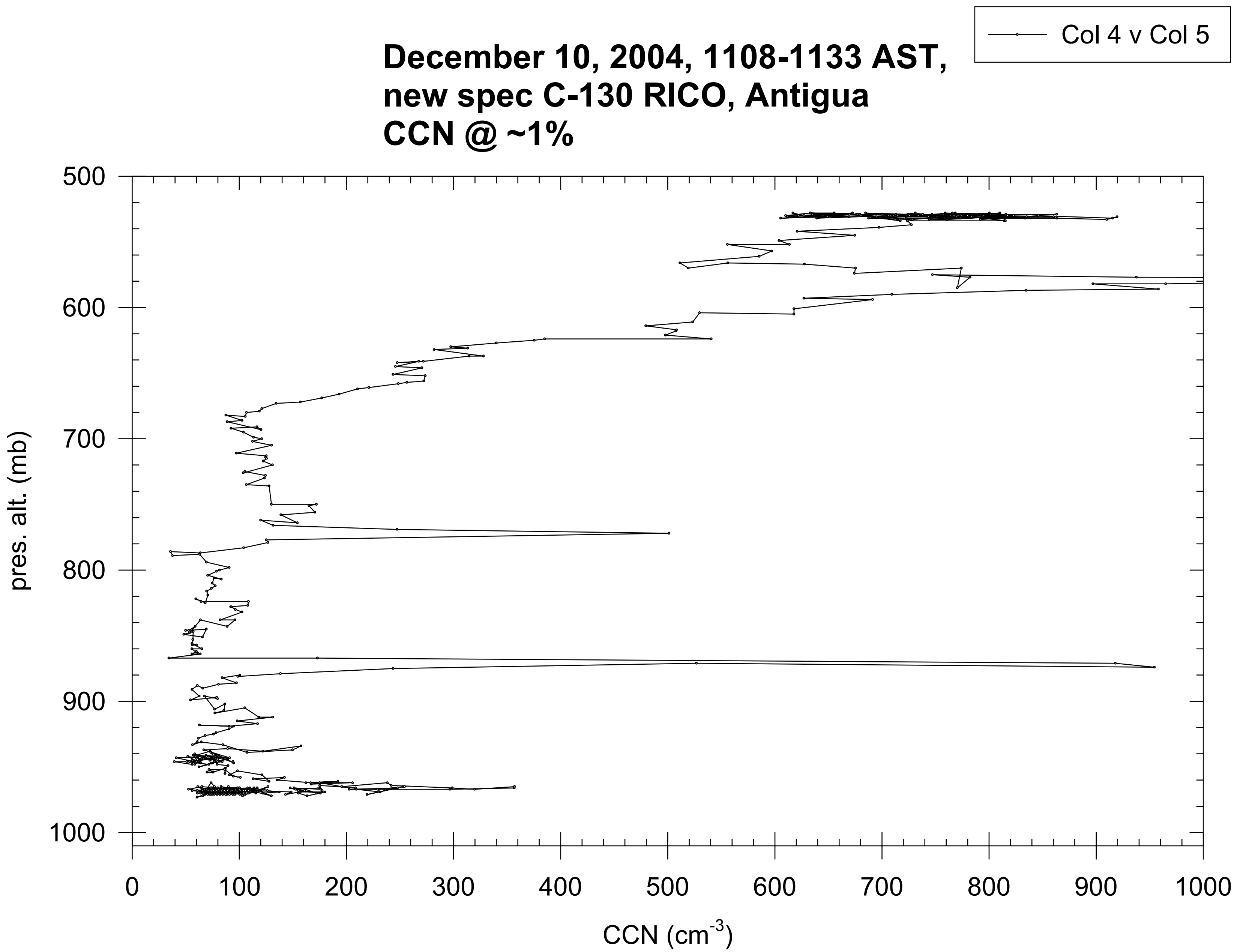
Dec 10, 2004 1730:30-1731:00 AST (2130:30-2131:00)
C-130 RICO, Antigua 788 mb
CN 457 cm^{-3} CCN @ 1% 25 cm^{-3}



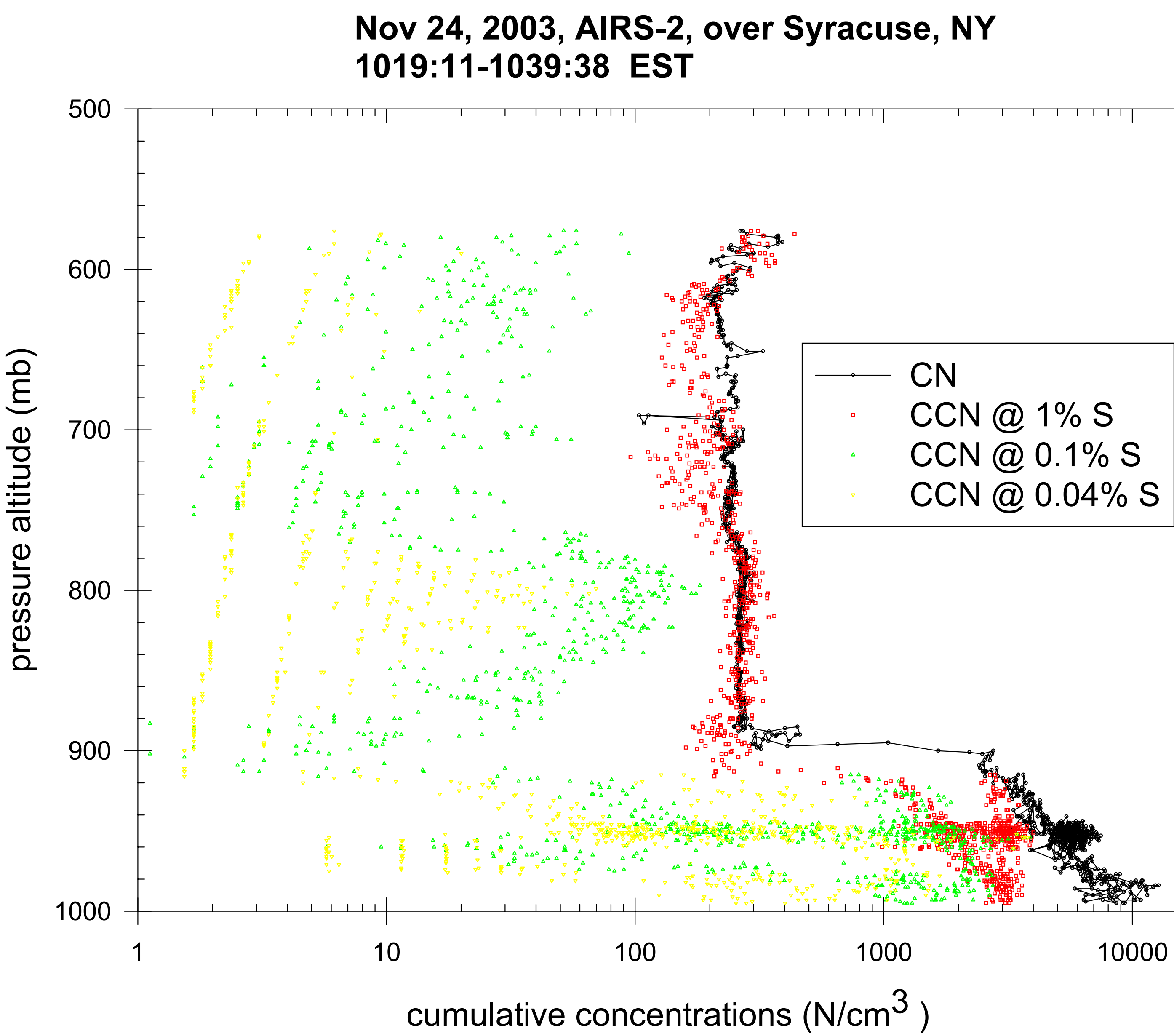
Dec 10, 2004 1730:30-1731:00 AST (2130:30-2131:00)
C-130 RICO, Antigua 788 mb
CN 457 cm^{-3} CCN @ 1% 25 cm^{-3}




May 15-17, 2003;
ARM-CART, OK
cumulative concentration, N(Sc < S)
S(%)
0.01
0.1
1
1
10
100
1000
15th 1835-1935
16th 0600-0630
17th 2215-2315



Col 4 v Col 5
December 10, 2004, 1108-1133 AST,
new spec C-130 RICO, Antigua
CCN @ ~1%
pres. alt. (mb)
500
600
700
800
900
1000
0
100
200
300
400
500
600
700
800
900
1000
CCN (cm-3)



Nov 24, 2003, AIRS-2, over Syracuse, NY
1019:11-1039:38 EST
pressure altitude (mb)
500
600
700
800
900
1000
1
10
100
1000
10000
cumulative concentrations (N/cm^3)
CN
CCN @ 1% S
CCN @ 0.1% S
CCN @ 0.04% S

Compare CCN spectra with cloud droplet concentrations to determine cloud supersaturations to better define CCN.

Compare CCN concentrations (spectra) with drizzle concentrations to assess 2nd indirect aerosol effect.